Appendix 3: Harper et al. 2000. Golden Crab Assessment.

UPDATED GOLDEN CRAB FISHERY TRENDS AND PRODUCTION MODEL ANALYSIS BASED ON TRIP REPORT LOGBOOK AND TRIP INTERVIEW DATA COLLECTION PROGRAMS

Report to the South Atlantic Fishery Management Council
Golden Crab Advisory Committee

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May 2000

Contribution Number PRD-99/00-12

INTRODUCTION

In November 1995, a voluntary logbook program for the golden crab fishery in the waters under the jurisdiction of the South Atlantic Fishery Management Council (SAFMC) was initiated by the National Marine Fisheries Service (NMFS). This Golden Crab Trip Report Logbook program became mandatory when regulations for the golden crab fishery management plan went into effect on October 28, 1996. Regulations require that all fishers that have been issued a Federal vessel permit for the golden crab fishery in the South Atlantic region must complete and submit a logbook form for each fishing trip on which golden crabs are caught. All reporting must be done on log forms that are provided by the Southeast Fisheries Science Center (SEFSC) and must be returned to the SEFSC for data processing.

Fishing activity for a single trip is reported on one log form. The form is designed so that fishers can report the catch, number of traps, fishing location, depth and soak time for each line or string of traps that are hauled during the trip.

For regulatory purposes, the South Atlantic region is divided into 3 golden crab fishing zones. The Northern Zone is defined as the EEZ north of 28 degrees N, latitude. The Middle Zone is defined as the EEZ from 25 degrees N, latitude to 28 degrees N, latitude. The Southern Zone is defined as the EEZ south of 25 degrees N, latitude. Federal vessel permits are issued for a specific zone and fishing is only allowed in the zone for which the permit is issued.

The purpose of the logbook program was to provide a suitable method of comprehensive data

collection for the fishery. Additional golden crab fishery data is available in the Trip Interview Program (TIP). TIP data collection is conducted by NMFS and state fishery agents who sample catches at the conclusion of commercial fishing trips and provides information on size frequency of individual crabs landed. Summaries of the Golden Crab Trip Report Logbook data have been previously reported (Harper, 1996; Harper and Scott, 1998; Harper and Eyo, 1999). In addition, Harper and Scott (1998) presented a preliminary production model analysis for the golden crab fishery. This report was prepared at the request of the SAFMC and corresponds to the report identified in the FY2000 Operations Plan negotiated between the Council and NMFS. This report summarizes logbook program and TIP sampling information available through the end of March 2000 and updates the golden crab fishery production model analysis.

Results and Discussion

The reporting regulations require that a logbook must be submitted for every trip where golden crabs are caught (possessed). If a permitted vessel did not fish during a calendar month, a report has to be submitted stating that the vessel was inactive with regard to golden crab fishing during that month. As of the end of March 2000, 695 logbook reports with catch and effort data for that trip have been submitted to the SEFSC.

Because no-fishing reports are required for a calendar month, the distribution of logbook submissions can be reviewed monthly. For the 12 month periods from November 1996 through October 1997 and November 1997 through October 1998, 25 and 18 permit holders submitted reports for every month respectively. For the period November 1998, through February 1999, 6 permit holders submitted a report for each month.

Reported Logbook Golden Crab Catches

Table 1 provides a monthly summary of the information for the 695 Golden Crab Trip Report Logbook forms which reported fishing activity. For the Middle Zone (area between 25° N, latitude and 28° N, latitude), estimated monthly golden crab catches from 538 trips completed during the entire period, November 1995 through March 2000, were 2.17 million pounds. Over the entire time period Middle Zone monthly catches averaged 41,011 pounds and ranged from 8,140 pounds for December 1998 to 84,872 pounds for May 1997 (Figure 1). Logbook report forms representing 157 trips with golden crab landings made in the Southern Zone (area south of 25º) between February 1997 and January 2000 were submitted. Southern Zone estimated golden crab catches for these reported trips were 692,327 and averaged 19,231 pounds per month over the thirty-six reported months.

Catch-per-unit-effort

The number of trap hauls reported for the 695 trips in the golden crab logbook database was 82,456 (Table 1, Figure 2). During the logbook time period the average number of traps hauled per month was 1,136 in the Middle Zone and 618 in the Southern Zone. Harper (1996) reported that golden crab catch-per-unit-effort as measured by mean catch (pounds) per trap haul was were highest

during the period November 1995 through March 1996. With additional trips over a longer time period available for calculations, CPUE trends appear to be exhibiting variable seasonal patterns with peak CPUE occurring in winter-spring (December through May) and lower CPUE values calculated during summer-fall (June through November). In general, CPUE trends declined slightly in both the Middle and Southern zones between 1995 and 1998 (Figure 3). However, the 1999 CPUE data indicated an increasing trend, especially in the Middle Zone. Although variable, the Southern Zone 1999 CPUE rates were significantly higher than previously reported levels, with peak CPUE of 62.9 pounds per trap haul occurring during August 1999.

Incidental catch

Incidental catch information was estimated by fishers and reported on the Golden Crab Trip Logbook forms. The most frequently reported incidental catch species was the giant isopod, *Bathynomus giganteus*. A total of 29,547 estimated pounds of giant isopod were caught between November 1995 and March 2000 (Table 2). The overall mean catch per trap haul was 0.36 pounds and ranged from 0.09 pounds during January 1999 to 0.89 pounds during October 1998. In general, reported incidental catch of other species was very low. In addition to the giant isopod, nine other categories of species or higher taxa representing a total incidental catch of 41.6 pounds over the period November 1995 through December 1998 were reported on the logbook forms. These categories and estimated catch were: rockfish - 13.3 pounds, hake - 6.0 pounds, red crab - 6.0 pounds, queen snapper - 4.3 pounds, jonah crab - 3.8 pounds, whiting - 3.0 pounds, squid - 2.2 pounds, shrimp - 2.0 pounds, and scorpion fish - 1.0 pounds.

TIP Sampling

TIP sampling of the golden crab fishery began during May 1995. A total of 63 trips have been sampled and 10,616 golden crabs have been measured through March 2000. For the purposes of this report, all golden crabs carapace width (CW) measurements were pooled by month regardless of area fished. This pooling of data is justified based upon research indicating that there was little difference in body size and weight characteristics between Atlantic and Gulf of Mexico collected golden crab samples (Trigg et.al., 1997). Table 3 presents the monthly number of crabs measured and carapace width statistics. The overall mean carapace width of sampled golden crabs was 146.4 mm. (N=10,616, std.=12.6) and ranged from 138.1 mm
(N=132,std.=12.3) during May 1998; to 157.7 mm. (N=161,std.=8.3) during January 1997
(Figure 5).

Updated Production Model Analysis

Catch and estimated effort data for the period 1986-present were refit with a non-equilibrium production model (Prager 1993) as described in Harper and Scott (1998). Golden crab quarterly catch in pounds for the South Atlantic region were obtained from the Accumulated Landings System for the period 1986 through October 1996. After 1996, golden crab catch was derived from the Golden Crab Trip Report Logbooks. Quarterly effort levels were estimated by dividing quarterly catch by

observed CPUE (lbs per trap haul). CPUE data for 1986 were available in Erdman (1990). CPUE for the most recent period (1996-1999) were from the Golden Crab Logbook Reports described earlier. The production model was fit to both quarterly and annual data. However, only 5 paired annual observations of catch and effort were available, making the annual model fits more dependent upon assumptions. Results of the quarterly and annual model fits depend upon assumptions made about the initial (1986) biomass level and for this update, we assumed that golden crab biomass was at carrying capacity at the beginning of 1986, rather than assuming the biomass was far from K. Quarterly catch and estimated effort data are provided in Table 4. For this analysis, as in Harper and Scott (1998), the first quarter of the fishing year ended in April and the last quarter ended in April of the following calendar year. For this analysis, a total of 56 quarters of catch (February of 1986 - January 2000) and 21 quarters of effort were available.

A total of 501 bootstrap fist of the model to the 21 paired catch and effort observations (Table 4) were used to estimate uncertainty in the model parameters of interest. As the model was fit to quarterly data, estimates of annual parameters, such as MSY or effort expected to result in MSY (f_{MSY}), can be obtained by multiplying the parameters of concern by 4. From this model, current biomass is estimated to be slightly below B_{MSY} after having increased from lower levels in the recent past while current fishing mortality is at about $F_{MSY.}$ Under this model, the approximate 80% confidence range for *quarterly* MSY resulting from this fit to the fishery data is about 144,000 to 186,000 lbs per quarter with a median estimate of 171,000 lbs per quarter for the fishery as it has historically operated (Table 5). This yield would be expected from a *quarterly* effort level of about 4,800 trap hauls (~4,400 - 5,500, approximate 80% CI) within the fishing grounds the fishery has historically exploited. These quarterly estimates translate into an annual median estimate for MSY of approximately 684,000 lbs and an annual median estimate for f_{MSY} of approximately 19,000 trap hauls per year within the areas and in the manner historically fished.

Fitting the model to the 5 annual catch and effort observations data results in more uncertain estimates of stock status, although the results are similar. In this case (Figure 6) current biomass is estimated to be slightly above $B_{MSY,}$ after having increased from a low in 1998 while fishing mortality is slightly below F_{MSY}. Under this model, the approximate 80% confidence range for *annual* MSY resulting from this fit to the fishery data is about 212,000 to 799,000 lbs per year with a median estimate of 673,000 lbs per year for the fishery as it has historically operated (Table 6). This yield would be expected from an annual effort level of about 22,100 trap hauls (~16,000 - 31,000, approximate 80% CI) within the fishing grounds and in the manner the fishery has historically operated. As indicated above, the quarterly estimates translated into annual estimates are more precisely determined and fall well within the confidence ranges for estimates of parameters based on annual data.

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Table 1. Monthly summary of information reported in the South Atlantic Golden Crab Trip Report Logbook (November 1995 through March 2000).

MIDDLE ZONE

Year	Month	Catch Weight (lbs)	Traps Hauled	Strings Hauled	Number Trips	Depth fished average (feet)	Soak Time average (days)
1995	November	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	December	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1996	January	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	February	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	March	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	April	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	June	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	July	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	August	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	September	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	October	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	November	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	December	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1997	January	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	February	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	March	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	April	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	June	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	July	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	August	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	September	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	October	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	November	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	December	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1998	January	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	February	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	March	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	April	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	June	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	July	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	August	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	September	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	October	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	November	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	December	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1999	January	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	February	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	March	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	April	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	June	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	July	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	August	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	September	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	October	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	November	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	December	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2000	January	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	February	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	March	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Overall	2,178,697	40,222	1,697	686	1,188	9.7

SOUTHERN ZONE

Year	Month	Catch Weight (lbs)	Traps Hauled	Strings Hauled	Number Trips	Depth fished average (feet)	Soak Time average (days)
1997	February	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	March	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	April	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	June	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	July	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	August	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	September	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	October	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	November	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	December	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1998	January	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	February	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	March	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	April	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	June	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	July	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	August	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	September	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	October	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	November	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	December	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1999	January						
	February						
	March						
	April						
	May						
	June	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	July	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	August	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	September	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	October	10	920	1	1	2,300	1.0
	November						
	December	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2000	January	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	February						
	March						
	Overall	602,927	32,284	428	197	1,760	18.6

Table 2. Estimated incidental giant isopod catches reported in the Golden Crab Trip Report Logbook, November 1995 through March 2000.

Year	Month	Catch POUNDS	Catch per trap haul POUNDS	Catch per year POUNDS
1995	November	203	0.52	
	December	405	0.34	611
1996	January	193	0.26	
	February	105	0.19	
	March	291	0.36	
	April	135	0.17	
	May	171	0.12	
	June	607	0.33	
	July	618	0.47	
	August	499	0.38	
	September	615	0.51	
	October	659	0.37	
	November	478	0.37	
	December	607	0.38	5,259
1997	January	593	0.31	
	February	447	0.33	
	March	612	0.32	
	April	941	0.47	
	May	2,269	0.42	
	June	965	0.38	
	July	691	0.24	
	August	641	0.30	
	September	621	0.56	
	October	780	0.41	
	November	570	0.28	
	December	615	0.56	9,052
1998	January	547	0.36	
	February	529	0.32	
	March	420	0.26	
	April	218	0.48	
	May	465	0.30	
	June	724	0.49	
	July	668	0.52	
	August	1,274	0.57	
	September	465	0.42	
	October	1,475	0.69	
	November	650	0.57	
	December	275	0.72	8,054
1999	January	85	0.39	
	February	144	0.12	
	March	540	0.26	
	April	414	0.26	
	May	231	0.33	
	June	570	0.3	
	July	567	0.29	
	August	653	0.59	
	September	630	0.43	
	October	275	0.34	
	November	218	0.2	
	December	495	0.37	7,340
2000	January	420	0.27	
	February	699	0.43	
	March	163	0.39	
	Total	29,547	0.36	

Table 3. Monthly summary of Trip Interview Program sampling for the golden crab fishery. Individual golden crabs from commercial landings are measured to the nearest mm. carapace width (CW) by NMFS and state port agents.

Year	Month	Number Measured	Mean CW(mm)	Standard Deviation	Minimum CW (mm)	Maximum CW (mm)
1995	May	74	150.5	10.7	122	177
	June	353	143.6	11.1	[illegible]	175
	July	211	147.3	15.0	102	180
	August	37	154.7	20.3	110	181
	September	475	142.5	8.3	106	180
	October	103	154.3	[illegible]	[illegible]	168
	November	202	155.0	14.0	105	183
	December	0				
1996	January	0				
	February	229	143.5	9.7	[illegible]	169
	March	25	[illegible]	[illegible]	120	180
	April	265	[illegible]	[illegible]	[illegible]	174
	May	357	[illegible]	11.2	104	170
	June	306	142.7	11.1	[illegible]	170
	July	170	150.4	11.2	[illegible]	171
	August	0				
	September	375	154.3	9.0	125	170
	October	123	155.1	11.1	124	180
	November	0				
	December	0				
1997	January	101	[illegible]	9.2	135	180
	February	0				
	March	[illegible]	155.0	[illegible]	125	182
	April	89	145.4	10.1	112	172
	May	212	151.9	9.2	122	174
	June	[illegible]	151.4	10.0	125	185
	July	0				
	August	43	152.7	9.3	130	170
	September	0				
	October	0				
	November	112	151.7	9.4	130	174
	December	0				
1998	January	0				
	February	0				
	March	0				
	April	0				
	May	132	139.1	12.3	[illegible]	172
	June	0				
	July	89	149.1	12.3	125	179
	August	315	148.0	10.5	120	185
	September	0				
	October	70	152.0	12.1	125	175
	November	124	148.8	[illegible]	121	170
	December	54	149.8	15.0	[illegible]	180
1999	January	0				
	February	354	[illegible]	11.5	114	175
	March	470	140.0	11.4	[illegible]	180
	April	275	138.5	11.0	110	160
	May	301	137.7	11.7	[illegible]	172
	June	607	143.0	11.6	[illegible]	168
	July	660	145.4	11.1	105	180
	August	412	145.3	10.6	120	183
	September	260	143.6	12.4	120	169
	October	217	150.0	12.0	125	185
	November	470	147.7	11.9	115	183
	December	125	144.6	11.5	122	180
2000	January	105	145.2	12.0	121	190
	February	273	154.0	10.6	125	181
	March	75	125.1	11.1	112	165
	Total	10,616	146.4	12.6	102	190

Table 4. Catch and effort data used in updated golden crab production models (negative values imply missing information).

Quarter	Month Range	Trap Hauls	Pounds
1	Feb - Apr 1986	23.02	2 029
2	May - Jul 1986	88 79	6 477
3	Aug - Oct 1986	49.52	4 137
4	Nov 1986 - Jan 1987	214 48	19 921
5	Feb - Apr 1987	-9	17 212
6	May - Jul 1987	-9	25 058
7	Aug - Oct 1987	-9	6 589
8	Nov 1987 - Jan 1988	-9	1 766
9	Feb - Apr 1988	-9	11 450
10	May - Jul 1988	-9	8 712
11	Aug - Oct 1988	-9	425
12	Nov 1988 - Jan 1989	-9	1 022
13	Feb - Apr 1989	-9	3 126
14	May - Jul 1989	-9	6 900
15	Aug - Oct 1989	-9	0
16	Nov 1989 - Jan 1990	-9	0
17	Feb - Apr 1990	-9	0
18	May - Jul 1990	-9	0
19	Aug - Oct 1990	-9	110
20	Nov 1990 - Jan 1991	-9	0
21	Feb - Apr 1991	-9	2 866
22	May - Jul 1991	-9	3 615
23	Aug - Oct 1991	-9	2 707
24	Nov 1991 - Jan 1992	-9	2 500
25	Feb - Apr 1992	-9	730
26	May - Jul 1992	-9	193
27	Aug - Oct 1992	-9	0
28	Nov 1992 - Jan 1993	-9	0
29	Feb - Apr 1993	-9	24 560
30	May - Jul 1993	-9	18 563
31	Aug - Oct 1993	-9	200
32	Nov 1993 - Jan 1994	-9	2 368
33	Feb - Apr 1994	-9	0
34	May - Jul 1994	-9	0
35	Aug - Oct 1994	-9	0
36	Nov 1994 - Jan 1995	-9	4 296
37	Feb - Apr 1995	-9	88 149
38	May - Jul 1995	-9	545 640
39	Aug - Oct 1995	-9	206 987
40	Nov 1995 - Jan 1996	4,941.31	193 630
41	Feb - Apr 1996	3,613.20	170 318
42	May - Jul 1996	10,862.88	527 869
43	Aug - Oct 1996	3,697.37	119 165
44	Nov 1996 - Jan 1997	4,148	161 650
45	Feb - Apr 1997	5,572	226 273
46	May - Jul 1997	11,035	405 251
47	Aug - Oct 1997	8,210	320 328
48	Nov 1997 - Jan 1998	4,707	152 356
49	Feb - Apr 1998	6,085	202 737
50	May - Jul 1998	4,357	117 450
51	Aug - Oct 1998	5,342	106 915
52	Nov 1998 - Jan 1999	2,085	41 140
53	Feb - Apr 1999	4,098	144 493
54	May - Jul 1999	4,603	183 255
55	Aug - Oct 1999	4,278	157 707
56	Nov 1999 - Jan 2000	4,055	162 703

Table 5. Results of the bootstrapped analysis for the production model fit to quarterly catch and effort data under the assumption that 1986 biomass was at model carrying capacity.

Param name	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL
B1ratio	2.000E+00	2.000E+00	0.00%	2.000E+00	2.000E+00	2.000E+00	2.000E+00
K	1.675E+06	1.666E+06	-0.51%	1.284E+06	2.361E+06	1.459E+06	1.960E+06
r	4.110E-01	4.146E-01	0.86%	2.554E-01	5.854E-01	3.345E-01	4.981E-01
q(1)	4.262E-05	4.331E-05	1.62%	2.775E-05	5.707E-05	3.423E-05	4.947E-05
MSY	1.710E+05	1.727E+05	1.02%	1.442E+05	1.860E+05	1.600E+05	1.791E+05
Bmsy	8.374E+05	8.332E+05	-0.51%	6.418E+05	1.180E+06	7.294E+05	9.798E+05
Fmsy	2.055E-01	2.073E-01	0.86%	1.277E-01	2.927E-01	1.672E-01	2.490E-01
fmsy(1)	4.791E+03	4.787E+03	-0.09%	4.169E+03	5.524E+03	4.453E+03	5.130E+03
B-ratio	9.770E-01	9.924E-01	1.57%	7.826E-01	1.167E+00	8.613E-01	1.078E+00
F-ratio	9.814E-01	9.549E-01	-2.71%	7.590E-01	1.381E+00	8.517E-01	1.153E+00

notes: B1ratio, Initial biomass expressed relative to Bmsy = K/2. A value of 2.0 implies initial biomass to be at model carrying capacity, K, r, model intrinsic rate of increase. q(1), catchability coefficient for fishery (1). MSY estimate of quarterly maximum sustainable yield. B-ratio, estimate of end of lsast quarter biomass, expressed relative to Bmsy. F-ratio, estimate of last quarter fishing mortality rate relative to that which could produce MSY. fmsy(1) estimate of the effort units needed to produce MSY for fishery (1).

Table 6. Results of the bootstrapped analysis for the production model fit to annual catch and effort data under the assumption that 1986 biomass was at model carrying capacity.

Param name	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL
B1ratio	2.000E+00	2.000E+00	0.00%	2.000E+00	2.000E+00	2.000E+00	2.000E+00
K	1.829E+06	1.696E+06	-7.27%	9.563E+05	5.003E+06	1.219E+06	3.121E+06
r	1.409E+00	1.651E+00	17.15%	2.406E-01	3.277E+00	7.412E-01	2.455E+00
q(1)	3.302E-05	3.780E-05	14.46%	9.497E-06	7.346E-05	1.637E-05	5.409E-05
MSY	6.728E+05	7.000E+05	4.05%	2.122E+05	7.990E+05	5.508E+05	7.548E+05
Ye(2000)	7.127E+05	6.893E+05	-3.28%	6.432E+05	7.712E+05	6.804E+05	7.485E+05
Bmsy	9.143E+05	8.479E+05	-7.27%	4.781E+05	2.501E+06	6.096E+05	1.560E+06
Fmsy	7.047E-01	8.256E-01	17.15%	1.203E-01	1.639E+00	3.706E-01	1.227E+00
fmsy(1)	2.209E+04	2.184E+04	-1.12%	1.559E+04	3.139E+04	1.841E+04	2.582E+04
B-ratio	1.103E+00	1.124E+00	1.84%	8.010E-01	1.438E+00	9.148E-01	1.303E+00
F-ratio	8.490E-01	8.409E-01	-0.95%	5.237E-01	1.515E+00	6.530E-01	1.134E+00

notes: B1ratio, Initial biomass expressed relative to Bmsy = K/2. A value of 2.0 implies initial biomass to be at model carrying capacity, K, r, model intrinsic rate of increase. q(1), catchability coefficient for fishery (1). MSY estimate of annual maximum sustainable yield. B-ratio, estimate of end of last year biomass, expressed relative to Bmsy. F-ratio, estimate of last year fishing mortality rate relative to that which could produce MSY. fmsy(1) estimate of the effort units needed to produce MSY for fishery (1).

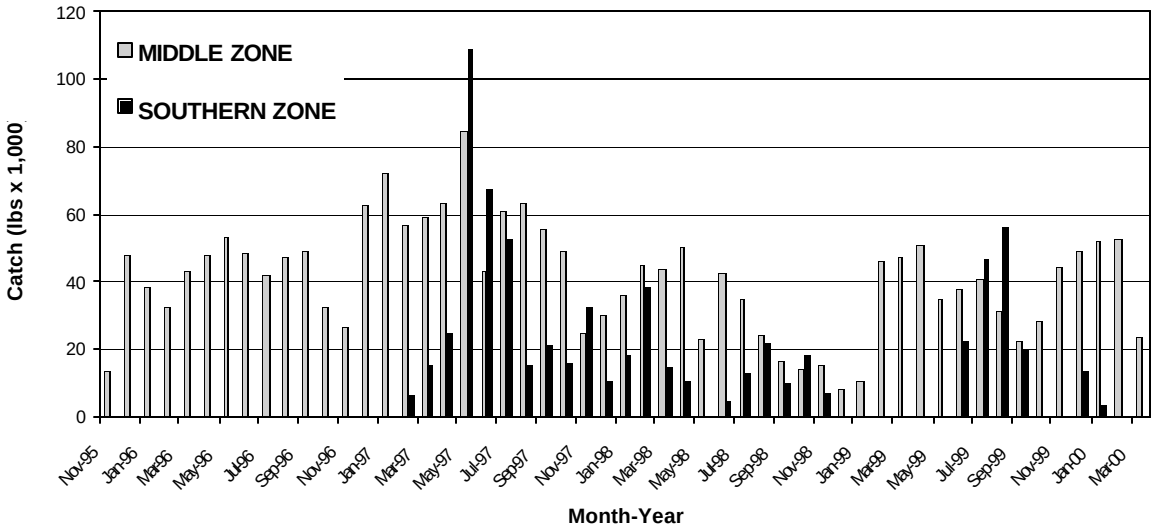


Figure 1. Reported catch by month and fishing zone from Golden Crab Trip Report Logbook data. A total of 695 trip forms reporting golden crab landings were submitted November 1995 through March 2000.

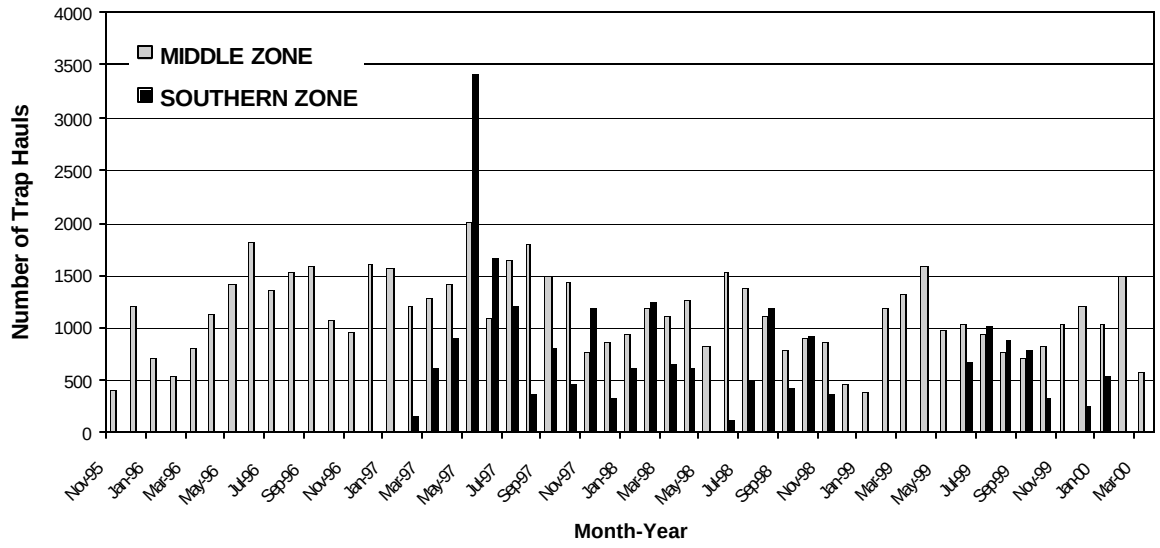


Figure 2. Reported number of traps hauled by month and fishing zone from the Golden Crab Trip Report Logbook data. A total of 695 logbook trip forms reporting golden crab landings were submitted November 1995 through March 2000.

Figure 3. Monthly CPUE (pounds per trap haul) reported for 538 middle zone trips with landings in the Golden Crab Trip Report Logbook, November 1995 through March 2000.

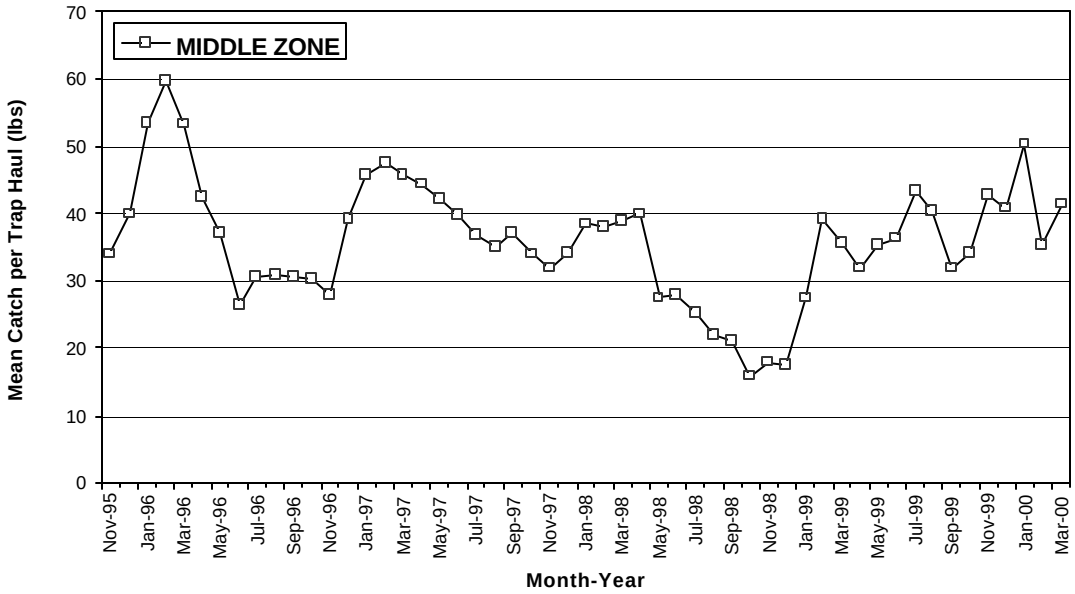
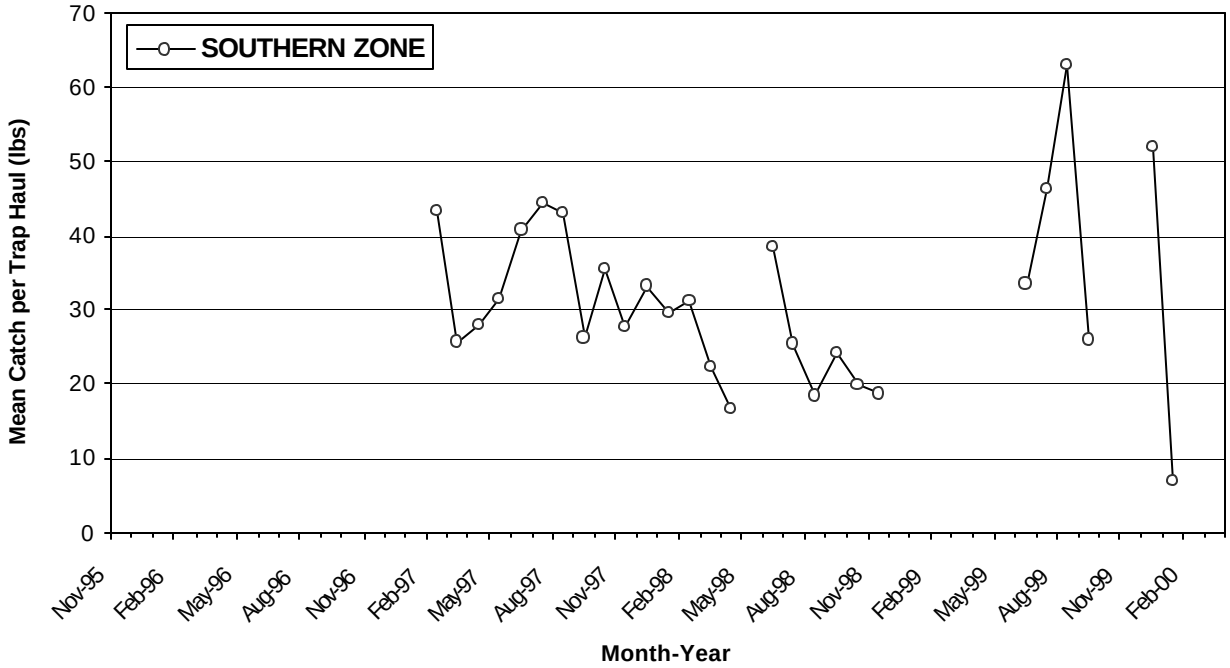


Figure 4. Monthly CPUE (pounds per trap haul) reported from 157 southern zone trips with landings in the Golden Crab Trip Report Logbook February 1997 through January 2000.



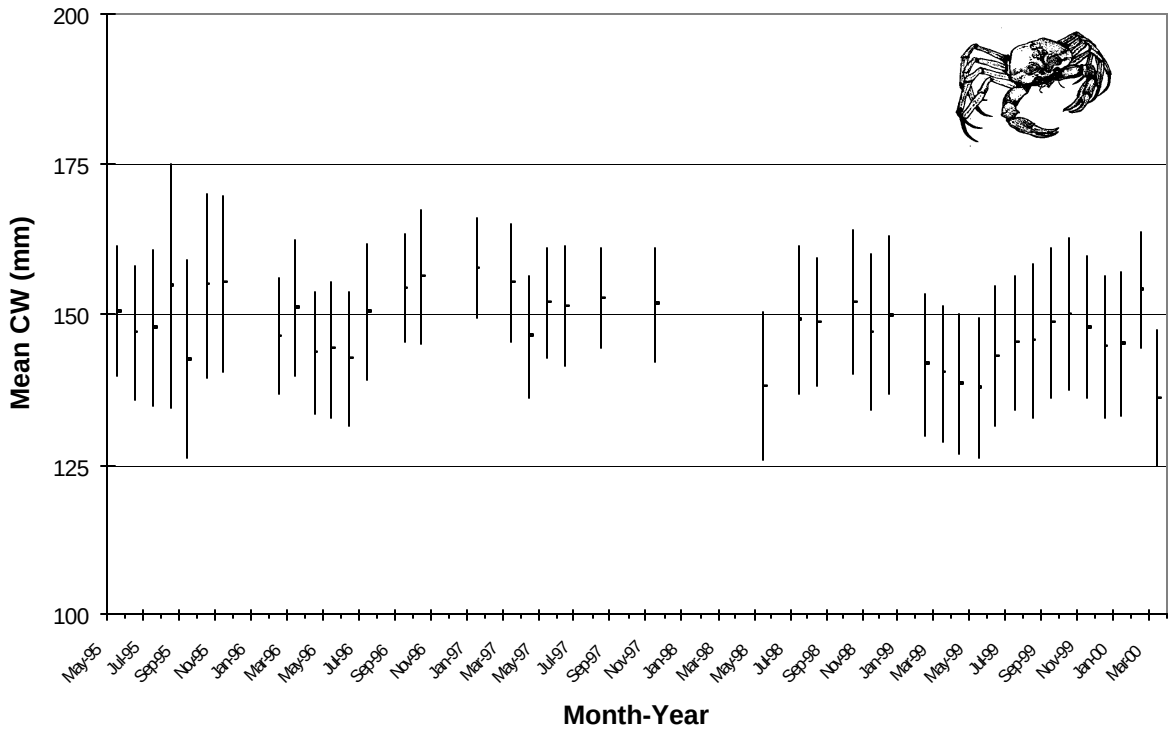
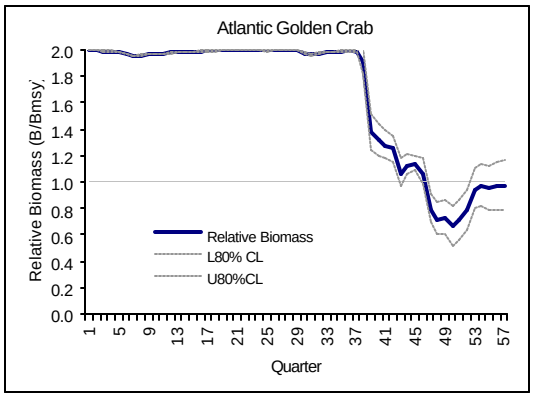


Figure 5. Mean Monthly Carapace Width (CW im millimeters) for golden crabs sampled from commercial catches, May 1995 through March 2000. Vertical lines indicate plus or minus one standard deviation from the mean.



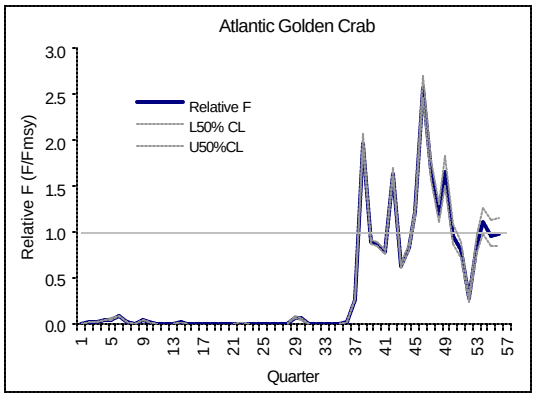
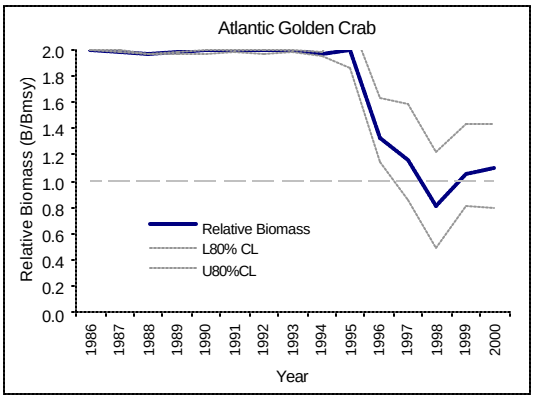


Figure 6. Median estimates of quarterly biomass (upper plate, solid line) and fishing mortality rate (lower plate, solid line) expressed relative to the levels estimated to produce MSY for the period 1986-1999, for the model assuming 1986 biomass was at carrying capacity fit to the 21 paired quarterly catch and effort observations. Dashed lines represent approximate 80% (upper) or 50% (lower) confidence ranges based on 501 bootstrap trials.



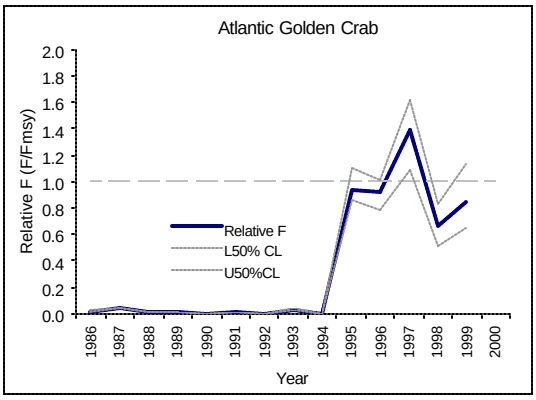


Figure 7. Median estimates of annual biomass (upper plate, solid line) and fishing mortality rate (lower plate, solid line) expressed relative to the levels estimated to produce MSY for the period 1986-1999, for the model assuming 1986 biomass was at carrying capacity fit to the 5 paired annual catch and effort observations. Dashed lines represent approximate 80% (upper) or 50% (lower) confidence ranges based on 501 bootstrap trials.